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Assignment 1

Due 25/8/2020

From the given data set, estimate the following models:

Capital Asset Pricing Model (CAPM)

CAPM: $$r_{jt} = \alpha_j + \beta_{j1} r_{mt} + \varepsilon_{jt} \qquad (1)$$

Fama & French three-factor Model (FF)

Fama & French: $$r_{jt} = \alpha_j + \beta_{j1} r_{mt} + \beta_{j2} r_{smbt} + \beta_{j3} r_{hmlt} + \varepsilon_{jt} \qquad (2)$$

Where:
- r_{jt} = excess return on portfolio *j* at time *t* and
- r_{mt} = excess return on market portfolio at time *t* – representing market risk premium.
- r_{smbt} = return on a small-stock portfolio minus the return on a large-stock portfolio (Small Minus Big) at time *t* – representing size premium.
- r_{hmlt} = return on a value-stock portfolio minus the return on a growth-stock portfolio (High Minus Low) at time *t* – representing value premium.

(1) Determine whether there exists significant Jensen Alpha.
(2) Determine whether portfolio *j* has the same risk as the market.
(3) Determine whether there exists significant size premium.
(4) Determine whether there exists significant growth (value) premium.
(5) Compare CAPM and FF models and determine which model is the most appropriated model. why?

To study calendar effect (January effects) from the data set, estimate the following models:

$$r_{jt} = \alpha_j + \gamma_j D_{1t} + \beta_{j1} r_{mt} + \beta_{j2} r_{smbt} + \beta_{j3} r_{hmlt} + \varepsilon_{jt} \qquad (3)$$

where: $D_{1t} = 1$ on January and $= 0$ otherwise.

(6) Determine whether there exist significant January effects.
(7) Make interpretation of estimated result of model (3) (including (1) sign, (2) overall test, (3) R-square, and (4) individual test).

$$\begin{aligned} r_{jt} = {} & \alpha_j + \beta_{j1} r_{mt} + \beta_{j2} r_{smbt} + \beta_{j3} r_{hmlt} \\ & + \gamma_j D_{1t} + \beta_{j1} D_{1t} r_{mt} + \beta_{j2} D_{1t} r_{smbt} + \beta_{j3} D_{1t} r_{hmlt} + \varepsilon_{jt} \end{aligned} \qquad (4)$$

(8) Perform Chow-test (using Intercept and Slope Dummy) whether January and other month share the same structure of the Fama-French model (Model (2) vs Model (4)).

Assume 95% Confidence level for all questions.

CAPM Model

```
. reg rj rm

      Source |       SS           df       MS      Number of obs   =    11,959
-------------+----------------------------------   F(1, 11957)     =   5988.94
       Model |  11449.5344         1  11449.5344   Prob > F        =    0.0000
    Residual |  22859.1346    11,957  1.91177842   R-squared       =    0.3337
-------------+----------------------------------   Adj R-squared   =    0.3337
       Total |   34308.669    11,958  2.86909759   Root MSE        =    1.3827

------------------------------------------------------------------------------
          rj |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          rm |   .9947206   .0128536    77.39   0.000     .9695254    1.019916
       _cons |   .0084273   .0126552     0.67   0.505    -.0163789    .0332335
------------------------------------------------------------------------------
```

$$\hat{r}_t = 0.0084 + 0.9947\, r_{mt} + \hat{u}_t$$

FF Model

```
. reg rj rm smb hml

      Source |       SS           df       MS      Number of obs   =    11,959
-------------+----------------------------------   F(3, 11955)     =   2057.22
       Model |  11681.1999         3  3893.73328   Prob > F        =    0.0000
    Residual |  22627.4691    11,955  1.89272013   R-squared       =    0.3405
-------------+----------------------------------   Adj R-squared   =    0.3403
       Total |   34308.669    11,958  2.86909759   Root MSE        =    1.3758

------------------------------------------------------------------------------
          rj |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          rm |   1.005554   .0128271    78.39   0.000     .9804104    1.030697
         smb |   .0371377   .0061189     6.07   0.000     .0251437    .0491318
         hml |   .0562866     .00609     9.24   0.000     .0443492     .068224
       _cons |   .0073088   .0125928     0.58   0.562    -.0173752    .0319928
------------------------------------------------------------------------------
```

$$\hat{r}_{jt} = .0073 + 1.0056\, r_{mt} + 0.0371\, r_{smbt} + 0.0563\, r_{hmlt} + \hat{u}_t$$

(1) $H_0 : \alpha = 0$

$H_a : \alpha \neq 0$

By using estimated CAPM model,

Since t-test falls into rejection region i.e. $\underbrace{P(t > 0.67)}_{0.505} > 0.05$

Then, the null hypothesis is not rejected. $\therefore$ Jensen Alpha is not significant.

(2) $H_0 : \beta_1 = 1$

$H_a : \beta_1 \neq 1$

Under CAPM model

t-test : $t = \dfrac{0.9947 - 1}{0.0129} = -0.4109$

P-value $= 0.6811 > \dfrac{0.05}{2}$

Since -0.4109 does not fall into rejection region, $\beta_1 = 1$ is not rejected.

$\therefore$ Portfolio have the same risk as the market.

(3) Under FF model

$H_0 : \beta_2 = 0$
$H_a : \beta_2 \neq 0$

$t = \frac{0.0371377 - 0}{0.0061189} = 6.07$

$P(t > 6.07) < \frac{0.05}{2}$

According to the STATA table, t-value falls into rejection region, therefore β_{j2} is significant.

(4) Under FF model

$H_0 : \beta_3 = 0$
$H_a : \beta_3 \neq 0$

$t = \frac{0.0562866 - 0}{0.00609} = 9.24$

$P(t > 9.24) < \frac{0.05}{2}$

According to the STATA table, t-value falls into rejection region, therefore β_3 is significant.

(5)

```
. reg rj rm smb hml
```

Source	SS	df	MS
Model	11681.1999	3	3893.73328
Residual	22627.4691	11,955	1.89272013
Total	34308.669	11,958	2.86909759

Number of obs	=	11,959
F(3, 11955)	=	2057.22
Prob > F	=	0.0000
R-squared	=	0.3405
Adj R-squared	=	0.3403
Root MSE	=	1.3758

rj	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
rm	1.005554	.0128271	78.39	0.000	.9804104	1.030697
smb	.0371377	.0061189	6.07	0.000	.0251437	.0491318
hml	.0562866	.00609	9.24	0.000	.0443492	.068224
_cons	.0073088	.0125928	0.58	0.562	-.0173752	.0319928

```
. test smb hml

 ( 1)  smb = 0
 ( 2)  hml = 0

       F(  2, 11955) =   61.20
            Prob > F =    0.0000
```

< 0.025 → F-value falls into rejection region which means $\beta_{smb} \neq 0$ or $\beta_{hml} \neq 0$

UR: $\hat{r}_{jt} = \alpha_j + \beta_{j1} r_{mt} + \beta_{j2} smb_t + \beta_{j3} hml_t + \hat{u}_t$

R: $\hat{r}_{jt} = \alpha_j + \beta_{j1} r_{mt} + \hat{u}_t$

$H_0 : \beta_{smb} = \beta_{hml} = 0$

$H_a : \beta_{smb} \neq 0$ or $\beta_{hml} \neq 0$

∴ FF model is more appropriate than CAPM.

(6)

```
. reg rj d1 rm smb hml
```

Source	SS	df	MS
Model	11683.8263	4	2920.95657
Residual	22624.8427	11,954	1.89265875
Total	34308.669	11,958	2.86909759

Number of obs	=	11,959
F(4, 11954)	=	1543.31
Prob > F	=	0.0000
R-squared	=	0.3406
Adj R-squared	=	0.3403
Root MSE	=	1.3757

rj	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d1	.05393	.045781	1.18	0.239	-.0358082	.1436682
rm	1.005405	.0128275	78.38	0.000	.9802607	1.030549
smb	.0369291	.0061214	6.03	0.000	.0249302	.048928
hml	.0562495	.00609	9.24	0.000	.0443121	.0681868
_cons	.0028773	.0131425	0.22	0.827	-.0228842	.0286388

$$r_{jt} = \alpha_j + \gamma_j D_{1t} + \beta_{j1} r_{mt} + \beta_{j2} r_{smbt} + \beta_{j3} r_{hmlt} + \varepsilon_{jt}$$

$$\hat{r}_t = \hat{\alpha} + 0.0539 D_{1t} + 1.0054 r_{mt} + 0.0369 r_{smbt} + 0.0562 r_{hmlt} + \hat{u}_t$$

$H_0: \gamma = 1$

$H_a: \gamma \neq 1$

$$t = \frac{0.05393 - 1}{0.045781} = -20.6651$$

$P(t > |-20.6651|) < 0.025 \rightarrow H_a$ is rejected which means $\gamma \neq 1$.

$\therefore$ There is not significant January effects.

(7) Make interpretation of estimated result of model (3) (including (1) sign, (2) overall test, (3) R-square, and (4) individual test).

$$r_{jt} = \alpha_j + \gamma_j D_{1t} + \beta_{j1} r_{mt} + \beta_{j2} r_{smbt} + \beta_{j3} r_{hmlt} + \varepsilon_{jt}$$

$$\hat{r}_t = \hat{\alpha}_j + 0.0539 D_{1t} + 1.0054 r_{mt} + 0.0369 r_{smbt} + 0.0562 r_{hmlt} + \hat{u}_t$$


```
. reg rj d1 rm smb hml
```

Source	SS	df	MS
Model	11683.8263	4	2920.95657
Residual	22624.8427	11,954	1.89265875
Total	34308.669	11,958	2.86909759

Number of obs	=	11,959
F(4, 11954)	=	1543.31
Prob > F	=	0.0000
R-squared	=	0.3406
Adj R-squared	=	0.3403
Root MSE	=	1.3757

rj	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d1	.05393	.045781	1.18	0.239	-.0358082	.1436682
rm	1.005405	.0128275	78.38	0.000	.9802607	1.030549
smb	.0369291	.0061214	6.03	0.000	.0249302	.048928
hml	.0562495	.00609	9.24	0.000	.0443121	.0681868
_cons	.0028773	.0131425	0.22	0.827	-.0228842	.0286388

$\hat{\beta}_{j1} > 1$

This implies if excess return on market (r_m) increases by 1, excess return on stock j would increase by 1.0054. The positive sign of beta means there is an positive correlation between r_{mt} and r_t. And it also implies that the stock is highly sensitive to the market.

$0 < \hat{\beta}_2 < 1$: This implies r_{smb} and r_t are positively correlated which means if r_{smb} increases by 1 unit, r_t would increase by less than 1 (0.0369).

$0 < \hat{\beta}_3 < 1$: Simlar to the interpretation of β_2 , r_{hmlt} and r_t are positively correlated which means if r_{smb} increases by 1 unit, r_t would increase by less than 1 (0.0562).

$0 < \hat{\gamma} < 1$: This implies D_{1t} has positive impact on r_t . It means if $D_1 = 1$ (when the special event occurs), excess return on the stock would increase by less than 1 (0.0539).

Overall test :

$H_0 : \gamma = \beta_1 = \beta_2 = \beta_3 = 0$

H_a : otherwise

$$F_{4, 11954} = 1543.31 \Rightarrow P(F > 1543.31) < 0.05$$

Since $P(F < 1543.31)$ does not exceed 0.05, F-value falls into rejection region. Therefore, H_0 rejected which means one or more than one estimated coefficients $\neq 0$.

R-square

According to the result, $R^2 = 0.3406$ which means 34.06% of r_t could be explained by the model. Since $0.3 < R^2 < 0.7$, it implies that the model generally has low effect size.

Individual test

- Test if γ is significant

$H_0 : \gamma = 0$ $\quad$ $t = 1.18 \Rightarrow P(t > 1.18) = 0.239 > 0.025$

$H_a : \gamma \neq 0$

Since $P(t > 1.18)$ exceeds 0.05, t-value does not fall into rejection region. Therefore, H_0 is not rejected meaning that γ is not significant.

- Test if β_1 is significant

$H_0 : \beta_1 = 0$ $\quad$ $t = 73.38 \Rightarrow P(t > 73.38) < 0.05$

$H_a : \beta_1 \neq 0$

H_0 is rejected since $P(t > 73.38) < 0.05$. Therefore, β_1 is significant.

- Test if β_2 is significant.

$H_0 : \beta_2 = 0$ $\quad$ $t = 6.03 \Rightarrow P(t > 6.03) < 0.05$

$H_a : \beta_2 \neq 0$

H_0 is rejected since $P(t > 6.03) < 0.05$. Therefore, β_2 is significant.

- Test if β_3 is significant

$H_0 : \beta_3 = 0$ $\quad$ $t = 9.24 \Rightarrow P(t > 9.24) < 0.05$

$H_a : \beta_3 \neq 0$

H_0 is rejected since $P(t > 9.24) < 0.05$. Therefore, β_3 is significant.

(8)

```
. reg rj rm smb hml d1 d1rm d1smb d1hml

      Source |       SS           df       MS      Number of obs   =    11,959
-------------+----------------------------------   F(7, 11951)     =    881.86
       Model |  11685.5157         7  1669.35938   Prob > F        =    0.0000
    Residual |  22623.1533    11,951  1.89299249   R-squared       =    0.3406
-------------+----------------------------------   Adj R-squared   =    0.3402
       Total |   34308.669    11,958  2.86909759   Root MSE        =    1.3759

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          rj |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          rm |   1.008159   .0133675    75.42   0.000     .9819563    1.034361
         smb |   .0364768   .0064084     5.69   0.000     .0239153    .0490383
         hml |   .0553364   .0063695     8.69   0.000     .0428511    .0678216
          d1 |   .0552912   .0461135     1.20   0.231    -.0350988    .1456811
        d1rm |   -.035594   .0475853    -0.75   0.454    -.1288689    .0576808
       d1smb |   .0037628   .0217997     0.17   0.863    -.0389682    .0464937
       d1hml |   .0106311   .0218876     0.49   0.627    -.0322721    .0535344
       _cons |   .0027652   .0131445     0.21   0.833    -.0230002    .0285307
------------------------------------------------------------------------------
```

$$\hat{r}_{jt} = 0.0028 + 1.0082\, r_{mt} + 0.0365\, r_{smbt} + 0.0553\, r_{hmlt} + 0.0553\, D_{1t} - 0.0356\, D_{1t} r_{mt} + 0.0038\, D_1 r_{smbt} + 0.0106\, D_{1t}\, r_{hmlt} + \hat{u}_t$$

① All : $r_t = \lambda_0 + \lambda_1 r_{mt} + \lambda_2 r_{smbt} + \lambda_3 r_{hmlt} + u_t \rightarrow$ FF Model

② $D_1 = 0$: $r_t = \alpha_0 + \alpha_1 r_{mt} + \alpha_2 r_{smbt} + \alpha_3 r_{hmlt} + u_t$

③ $D_1 = 1$: $r_t = \beta_0 + \beta_1 r_{mt} + \beta_2 r_{smbt} + \beta_3 r_{hmlt} + u_t$

```
. reg rj rm smb hml if d1==0

      Source |       SS           df       MS      Number of obs   =    10,974
-------------+----------------------------------   F(3, 10970)     =   1887.21
       Model |  10805.6192  RSS2  3  3601.87308   Prob > F        =    0.0000
    Residual |   20936.975    10,970  1.90856654   R-squared       =    0.3404
-------------+----------------------------------   Adj R-squared   =    0.3402
       Total |  31742.5942    10,973  2.89279087   Root MSE        =    1.3815

------------------------------------------------------------------------------
          rj |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          rm |   1.008159   .0134224    75.11   0.000     .9818484    1.034469
         smb |   .0364768   .0064347     5.67   0.000     .0238636      .04909
         hml |   .0553364   .0063956     8.65   0.000     .0427998    .0678729
       _cons |   .0027652   .0131985     0.21   0.834    -.0231062    .0286367
------------------------------------------------------------------------------
```

→ ②

```
. reg rj rm smb hml if d1==1

      Source |       SS           df       MS      Number of obs   =       985
-------------+----------------------------------   F(3, 981)       =    169.11
       Model |  872.032797  RSS3  3  290.677599   Prob > F        =    0.0000
    Residual |  1686.17832       981  1.71883621   R-squared       =    0.3409
-------------+----------------------------------   Adj R-squared   =    0.3389
       Total |  2558.21111       984  2.59980804   Root MSE        =     1.311

------------------------------------------------------------------------------
          rj |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          rm |   .9725647   .0435176    22.35   0.000     .8871664    1.057963
         smb |   .0402395   .0198549     2.03   0.043     .0012766    .0792024
         hml |   .0659675   .0199538     3.31   0.001     .0268104    .1051246
       _cons |   .0580564   .0421181     1.38   0.168    -.0245956    .1407084
------------------------------------------------------------------------------
```

→ ③

$RSS_1 = 22627.4691$

$RSS_2 = 20936.975$

$RSS_3 = 1686.17832$

$k = 3,\ n_1 = 10{,}974,\ n_2 = 985$

Chow test

H_0 : $\alpha_0 = \beta_0 = \lambda_0$
and $\alpha_1 = \beta_1 = \lambda_1$
and $\alpha_2 = \beta_2 = \lambda_2$
and $\alpha_3 = \beta_3 = \lambda_3$

H_a : otherwise

$$F = \frac{(RSS_1 - RSS_2 - RSS_3)/k}{(RSS_2 + RSS_3)/(n_1 + n_2 - 2k)}$$

$$= \frac{(22627.4691 - 20936.975 - 1686.17832)/3}{(20936.975 + 1686.17832)/(10{,}974 + 985 - 2(3))}$$

$$= 0.76008 \rightarrow p\text{-value} = 0.48 > 0.05$$

H_0 is not rejected since p-value > 0.05.

$\therefore$ January and other month still share the same structure as FF model.